White Paper: Geo-neutrinos

Subgroup Association: Astrophysical and Cosmological Neutrinos; Neutrinos and Society
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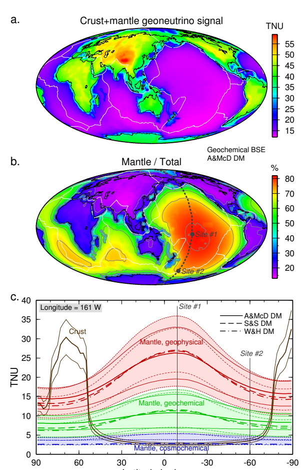
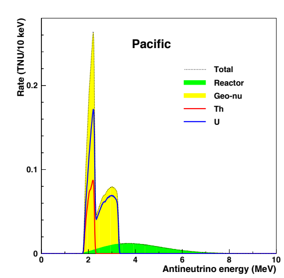
Neutrino geoscience is branch of applied neutrino science made possible by the commissioning of large underground detectors and our recently acquired understanding of neutrino properties. It provides fundamental information on terrestrial radiogenic heating with important implications for the origin and thermal history of our planet[1]. It is a multidisciplinary endeavor bridging neutrino physics, geochemistry, and geophysics in a synergy of scientific inquiry.

Geo-neutrino measurement is established by virtue of experimental neutrino science, demonstrated by the KamLAND[2] and Borexino[3] projects, with SNO+[4] soon to begin contributing. Several larger projects, Hanohano[5], LENA[6], and Daya Bay II, are being considered. These scintillation detectors have primary goals of measuring reactor, solar, and supernova neutrinos; they employ the traditional inverse beta decay reaction on hydrogen to gain sensitivity to geo-neutrinos from uranium and thorium. New detection techniques in prototype development aim to image the interaction, improving directional resolution. Measurement of potassium geo-neutrinos, with energy below the inverse neutron decay threshold, might be enabled by directional dark matter detectors through elastic scattering on electrons, or by instrumenting nuclear targets with lower inverse beta decay threshold energy, such as ^{106}Cd. Geo-neutrinos are background to signals from reactor antineutrinos and relic supernova neutrinos, and possibly to direct dark matter searches. Measuring their direction and characterizing their flux improves the physics reach of these studies while contributing fundamental geological information.

The growing maturity of neutrino geosciences is manifest by a series of international workshops, beginning in Hawaii in 2005 and 2007, continuing in Canada in 2008, in Italy in 2010, and in Japan this year. These gatherings of physicists and earth scientists maintain a venue for sharing progress, cross-disciplinary instruction, and building collaborations; they establish a fruitful scientific synergy.

Until the commissioning of a dedicated detector, ideally deployed at a deep ocean site, geo-neutrino measurements remain a byproduct of physics experiments. There are many interesting challenges confronting the full extraction of geological information from these physics experiments. Of primary importance are improved knowledge of the neutrino oscillation parameters, reactor antineutrino fluxes, and local distributions of uranium and thorium. New detection techniques provided by direct dark matter detectors, including novel nuclear targets and elastic scattering on electrons, provide opportunities to expand sensitivity to potassium geo-neutrinos.





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